CLAIMS

What is claimed is:

1. An interference detection apparatus for use in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection apparatus detects the presence of interference in a selected RF channel, comprising:

(a) a radio/modem device adapted to receive the RF signals, wherein the radio/modem is responsive to channel control signals that select one of the plurality of RF channels, and wherein the radio/modem produces a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel;

(b) a plurality of tracking/register (T/R) filter blocks, switchably coupled to the radio/modem device, wherein each T/R filter block is associated with and corresponds to a unique RF channel, and wherein each T/R filter block receives an RSSI measurement from the radio/modem for its associated and corresponding RF channel, and wherein each T/R filter block produces and maintains noise and interference estimates for its corresponding and associated RF channel;

(c) an average noise estimation block, coupled to the plurality of T/R filter blocks, and capable of receiving the noise estimates stored in the T/R filter blocks, wherein the average noise estimation block outputs an average noise estimate of all of the noise estimates stored in the plurality of T/R filter blocks; and

(d) an interference present decision block, switchably coupled to the plurality of T/R filter blocks and adapted to receive the average noise estimate from the average noise estimation block, wherein the interference present decision block outputs an interference present indication for a selected RF channel if the interference estimate stored in its associated and corresponding T/R filter block exceeds the average noise estimate by a threshold value.

2. The interference detection apparatus of Claim 1, wherein the RSSI measurement produced by the radio/modem device is proportional to received power or magnitude of the corresponding RF signal.

3. The interference detection apparatus of Claim 1, wherein the RSSI measurement produced by the radio/modem device comprises a magnitude estimate based on in-phase (I) and quadrature (Q) outputs of an analog-digital (A/D) converter.

4. The interference detection apparatus of Claim 1, wherein the A/D converter comprises a Delta Sigma Modulator.

5. The interference detection apparatus of Claim 3, wherein the magnitude estimate is produced in accordance with the following equation:

$$Metric = \sum_{N} \left(\max\left(|I|,|Q|\right) + \tfrac{1}{2}\min\left(|I|,|Q|\right)\right).$$

6. The interference detection apparatus of Claim 3, wherein the magnitude estimate is produced in accordance with the following equation:

$$Metric = \sum_{N} \sqrt{I^2 + Q^2}\ .$$

7. The interference detection apparatus of Claim 1, wherein the RSSI measurement produced by the radio/modem device comprises a power estimate based on in-phase (I) and quadrature (Q) outputs of a Delta Sigma Modulator.

8. The interference detection apparatus of Claim 1, wherein the power estimate is produced in accordance with the following equation:

$$Metric = \sum_{N} \left(I^2 + Q^2\right),$$

and wherein N comprises the number of samples taken during an observation period.

9. The interference detection apparatus of Claim 1, wherein the RSSI measurements produced by the radio/modem device are input to the T/R filter blocks during an observation/data collection phase of a bad channel assessment algorithm.

10. The interference detection apparatus of Claim 1, wherein the T/R filter blocks comprise:

(a) a low value T/R filter, wherein the low value T/R filter tracks noise in a corresponding and associated channel; and

(b) a high value T/R filter, wherein the high value T/R filter tracks interference in a corresponding and associated channel.

11. The interference detection apparatus of Claim 10, wherein the low value T/R filter comprises:

(a) a comparator block, having a first and second input and an output, wherein the first input is coupled to receive the RSSI measurement from the radio/modem device;

(b) a multiplexer, having a first and second input and an output, and having a selection input coupled to the output of the comparator, wherein the first multiplexer input is coupled to receive the RSSI measurement;

(c) a low register, having an input and an output, wherein the input is coupled to the output of the multiplexer, and wherein the low register output is coupled to the second input of the comparator block; and

(d) an amplifier, having an input coupled to receive the output of the low register, and having an output coupled to the second input of the multiplexer;

wherein the low value T/R filter tracks noise in a corresponding channel by inputting an RSSI measurement during an observation phase, comparing the inputted measurement to contents of the low register, and loading the low register with the inputted RSSI measurement if it is lower than the contents, else loading the low register with an amplified version of the low register contents, as amplified by the amplifier.

12. The interference detection apparatus of Claim 11, wherein the amplifier has a scale factor slightly greater than unity.

13. The interference detection apparatus of Claim 12, wherein the scale factor provided by the amplifier is of the form $1+1/2^K$.

14. The interference detection apparatus of Claim 12, wherein variations in the scale factor control an amount of decay in the low register contents.

15. The interference detection apparatus of Claim 10, wherein the high value T/R filter comprises:

(a) a comparator block, having a first and second input and an output, wherein the first input is coupled to receive the RSSI measurement from the radio/modem device;

(b) a multiplexer, having a first and second input and an output, and having a selection input coupled to the output of the comparator, wherein the first multiplexer input is coupled to receive the RSSI measurement;

(c) a high register, having an input and an output, wherein the input is coupled to the output of the multiplexer, and wherein the high register output is coupled to the second input of the comparator block; and

(d) an amplifier, having an input coupled to receive the output of the high register, and having an output coupled to the second input of the multiplexer;

wherein the high value T/R filter tracks noise in a corresponding channel by inputting an RSSI measurement during an observation phase, comparing the inputted measurement to contents of the high register, and loading the high register with the inputted RSSI measurement if it is greater than the contents, else loading the high register with an amplified version of the high register contents, as amplified by the amplifier.

16. The interference detection apparatus of Claim 15, wherein the amplifier has a scale factor slightly less than unity.

17. The interference detection apparatus of Claim 16, wherein the scale factor provided by the amplifier is of the form $1-1/2^K$.

18. The interference detection apparatus of Claim 10, wherein the low value T/R filter comprises:

(a) a comparator block, having a first and second input and an output, wherein the first input is coupled to receive the RSSI measurement from the radio/modem device;

(b) a low register, having an input and an output, wherein the input is coupled to the comparator block output; and

(c) an amplifier, having an input coupled to receive the output of the low register, and having an output coupled to the second input of the comparator;

wherein the low value T/R filter tracks noise in a corresponding channel by inputting an RSSI measurement during an observation phase, comparing the inputted measurement to amplified contents of the low register, as amplified by the amplifier, and loading the low register with the inputted RSSI measurement if it is lower than the amplified contents, else loading the low register with the amplified contents.

19. The interference detection apparatus of Claim 18, wherein the amplifier has a scale factor slightly greater than unity.

20. The interference detection apparatus of Claim 19, wherein the scale factor provided by the amplifier is of the form $1+1/2^K$.

21. The interference detection apparatus of Claim 19, wherein variations in the scale factor control an amount of decay in the low register contents.

22. The interference detection apparatus of Claim 10, wherein the high value T/R filter comprises:

(a) a comparator block, having a first and second input and an output, wherein the first input is coupled to receive the RSSI measurement from the radio/modem device;

(b) a high register, having an input and an output, wherein the input is coupled to the comparator block output; and

(c) an amplifier, having an input coupled to receive the output of the high register, and having an output coupled to the second input of the comparator;

wherein the high value T/R filter tracks noise in a corresponding channel by inputting an RSSI measurement during an observation phase, comparing the inputted measurement to amplified contents of the high register, as amplified by the amplifier, and loading the high register with the inputted RSSI measurement if it is greater than the amplified contents, else loading the high register with the amplified contents.

23. The interference detection apparatus of Claim 22, wherein the amplifier has a scale factor slightly less than unity.

24. The interference detection apparatus of Claim 23, wherein the scale factor provided by the amplifier is of the form $1-1/2^K$.

25. The interference detection apparatus of Claim 10, wherein the T/R filter blocks further include a duty cycle estimation filter, wherein the duty cycle estimation filter estimates a probability that an interferer is present in a selected channel.

26. The interference detection apparatus of Claim 25, wherein the duty cycle estimation filter comprises:

(a) an averaging block, adapted to receive noise data from the low value T/R filter and interference data from the high value T/R filter, wherein the averaging block outputs a computed average of the noise and interference data;

(b) a comparator block, having a first input coupled to receive the computed average output by the averaging block, and a second input coupled to receive the RSSI measurement, and wherein the comparator block also has an output; and

(c) an integrator block, wherein the integrator block is coupled to receive the comparator block output;

and wherein the comparator block compares the computed average with the RSSI measurement and outputs a logical one value if the RSSI measurement is greater than the computed average, else the comparator block outputs a logical zero, and wherein the integrator block outputs a value that is approximately equal to a probability that an interferer is present on a selected channel.

27. The interference detection apparatus of Claim 26, wherein the computed average comprises an average of the high and low register contents over several observation periods.

28. The interference detection apparatus of Claim 26, wherein the computed average comprises a weighted average of noise and interference measurements.

29. The interference detection apparatus of Claim 26, wherein the averaging block uses a scaled version of the noise data to produce the computed average.

30. The interference detection apparatus of Claim 10, further including an observation accelerator circuit comprising:

(a) an averaging block, adapted to receive noise data from the low value T/R filter and interference data from the high value T/R filter, wherein the averaging block outputs a computed average of the noise and interference data;

(b) a comparator block, having a first input coupled to receive the computed average output by the averaging block, and a second input coupled to receive the RSSI measurement, and wherein the comparator block also has an output;

(c) an interference observation counter, having an input coupled to the comparator block output, and having an output, wherein the interference counter maintains a count of the number of interference measurements found in a selected channel;

(d) an observation counter, adapted to maintain a count of the number of observations made of the selected channel, wherein the observation counter has an output; and

(e) an observation completion block, coupled to receive the outputs of both the interference observation counter and the observation counter,

wherein observation of the selected channel ceases if either the interference observation counter equals a predetermined interference threshold value (N_{inter}) or the observation counter equals a predetermined total observation count value (N_{obs}).

31. The interference detection apparatus of Claim 1, wherein the average noise estimation block comprises:

(a) an arithmetic average calculation block, having an input and an output, wherein the arithmetic average calculation block is adapted to receive noise data from each low value T/R filter, wherein the arithmetic average calculation block produces a computed average of the noise data;

(b) a comparator block, having a first input switchably coupled to selectively receive noise data from each low value T/R filter, and having a second input, and wherein the comparator block also has an output; and

(c) an amplifier, having an input coupled to the output of the arithmetic average calculation block, and having an output coupled to the second input of the comparator block,

wherein the computed average of all T/R filter noise data is scaled by the amplifier, and compared to the noise data of a selected T/R filter, and wherein if the selected T/R filter noise exceeds the scaled computed average, the selected T/R filter noise is excluded from the weighted average noise estimate output by the comparator block.

32. The interference detection apparatus of Claim 1, wherein the average noise estimate comprises a simple arithmetic average of all of the noise estimates stored in the plurality of T/R filter blocks.

33. The interference detection apparatus of Claim 1, wherein the average noise estimate comprises a weighted average of all of the noise estimates stored in the plurality of T/R filter blocks.

34. The interference detection apparatus of Claim 1, wherein the interference present decision block scales the average noise estimate to produce a scaled average noise estimate, and wherein the interference present decision block compares the interference estimate stored in a selected T/R filter block with the scaled average noise estimate, and outputs an interference present indication for its associated and corresponding RF channel if the interference estimate is equal to or greater than the scaled average noise estimate.

35. The interference detection apparatus of Claim 34, wherein the scaled average noise estimate is obtained by scaling the average noise estimate by a factor of $1+1/2^K$.

36. An interference detection apparatus for use in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection apparatus detects the presence of interference in a selected RF channel, comprising:

(a) a radio/modem device adapted to receive the RF signals, wherein the radio/modem is responsive to channel control signals that select one of the plurality of RF channels, and wherein the radio/modem produces a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel;

(b) a plurality of tracking/register (T/R) filter blocks, switchably coupled to the radio/modem device, wherein each T/R filter block is associated with and corresponds to a unique RF channel, and wherein each T/R filter block receives an RSSI measurement from the radio/modem for its associated and corresponding RF channel, and wherein each T/R filter block produces and maintains noise and interference estimates for its corresponding and associated RF channel; and

(c) an interference present decision block, switchably coupled to the plurality of T/R filter blocks, wherein the interference present decision block compares the interference estimate of the selected T/R filter block with a threshold value and outputs an interference present indication for its associated and corresponding RF channel if the interference estimate is equal to or greater than the threshold value.

37. The interference detection apparatus of Claim 36, wherein the threshold value comprises the noise estimate stored in the selected T/R filter block.

38. The interference detection apparatus of Claim 36, wherein the threshold value comprises a scaled version of the noise estimate stored in the selected T/R filter block.

39. The interference detection apparatus of Claim 38, wherein the scaled version of the noise estimate stored in the selected T/R filter block is obtained by scaling the noise estimate by a factor of $1+1/2^K$.

40. An interference detection apparatus for use in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection apparatus detects the presence of interference in a selected RF channel, comprising:

(a) means for producing a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel, wherein the RSSI measurement producing means is adapted to receive the RF signals, and wherein the RSSI measurement producing means is responsive to channel control signals that select one of the plurality of RF channels;

(b) a plurality of tracking/register (T/R) filtering means for tracking noise and interference levels in corresponding and associated RF channels, wherein the T/R filtering means are switchably coupled to the RSSI measurement producing means, and wherein each T/R filtering means is associated with and corresponds to a unique RF channel, and wherein each T/R filtering means inputs an RSSI measurement for its associated and corresponding RF channel, and wherein each T/R filtering means maintains noise and interference estimates for its associated and corresponding RF channel;

(c) means, coupled to the plurality of T/R filtering means, for calculating an average noise estimate of all of the noise estimates maintained by the plurality of T/R filtering means; and

(d) means, switchably coupled to the plurality of T/R filtering means and coupled to the average noise estimate calculating means, for determining presence of interference in a selected RF channel, wherein the interference presence determining means compares the interference estimate, stored in the T/R filtering means associated and corresponding to the selected RF channel, to the average noise estimate and outputs an interference present indication for the selected RF channel if the interference estimate exceeds the average noise estimate by a threshold value.

41. The interference detection apparatus of Claim 40, wherein the average noise estimate comprises a simple arithmetic average of all of the noise estimates stored in the plurality of T/R filtering means.

42. The interference detection apparatus of Claim 40, wherein the average noise estimate comprises a weighted average of all of the noise estimates stored in the plurality of T/R filtering means.

43. The interference detection apparatus of Claim 40, wherein the interference presence determining means scales the average noise estimate to produce a scaled average noise estimate, and wherein the interference presence determining means compares the interference estimate stored in a selected T/R filtering means with the scaled average noise estimate and outputs an interference present indication for its associated and corresponding RF channel if the interference estimate is equal to or greater than the scaled average noise estimate.

44. An interference detection apparatus for use in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection apparatus detects the presence of interference in a selected RF channel, comprising:

(a) means for producing a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel, wherein the RSSI measurement producing means is adapted to receive the RF signals, and wherein the RSSI measurement producing means is responsive to channel control signals that select one of the plurality of RF channels;

(b) a plurality of tracking/register (T/R) filtering means for tracking noise and interference levels in corresponding and associated RF channels, wherein the T/R filtering means are switchably coupled to the RSSI measurement producing means, and wherein each T/R filtering means is associated with and corresponds to a unique RF channel, and wherein each T/R filtering means inputs an RSSI measurement for its associated and corresponding RF channel, and wherein each T/R filtering means maintains noise and interference estimates for its associated and corresponding RF channel; and

(c) means, switchably coupled to the plurality of T/R filtering means, for determining presence of interference in a selected RF channel, wherein the interference presence determining means compares the interference estimate of a selected T/R filtering means with a threshold value and outputs an interference present indication for its associated and corresponding RF channel if the interference estimate is equal to or greater than the threshold value.

45. The interference detection apparatus of Claim 44, wherein the threshold value comprises the noise estimate stored in the selected T/R filtering means.

46. The interference detection apparatus of Claim 44, wherein the threshold value comprises a scaled version of the noise estimate stored in the selected T/R filtering means.

47. A method of detecting interference in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection method detects the presence of interference in a selected RF channel, comprising:

(a) generating a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel;

(b) tracking noise and interference estimates for each of the plurality of RF channels, wherein the noise and interference estimates are derived from the RSSI measurements generated in step (a);

(c) calculating an average noise estimate of all of the noise estimates tracked in step (b); and

(d) indicating that interference is present on a selected RF channel if the interference estimate tracked for the selected RF channel in step (b) exceeds the average noise estimate calculated in step (c) by a threshold value.

48. The method of detecting interference in a wireless communication system as set forth in Claim 47, wherein the step (d) of indicating that interference is present on a selected RF channel comprises the following sub-steps:

(1) calculating a simple arithmetic average of all of the noise estimates tracked in step (b);

(2) scaling the arithmetic average by a predetermined scale factor;

(3) comparing the scaled arithmetic average to the interference estimate of the selected RF channel; and

(4) indicating that interference is present on the selected RF channel if the interference estimate is greater than or equal to the scaled arithmetic average, else indicating that interference is absent from the selected RF channel.

49. The method of detecting interference in a wireless communication system as set forth in Claim 47, wherein the step (d) of indicating that interference is present on a selected RF channel comprises the following sub-steps:

(1) calculating a weighted average of all of the noise estimates tracked in step (b);

(2) scaling the weighted average by a predetermined scale factor;

(3) comparing the scaled weighted average to an interference estimate of the selected RF channel; and

(4) indicating that interference is present on the selected RF channel if the interference estimate is greater than or equal to the scaled weighted average, else indicating that interference is absent from the selected RF channel.

50. A method of detecting interference in a wireless communication system, wherein the wireless communication system includes a plurality of radio frequency (RF) channels transmitting RF signals, and wherein the interference detection method detects the presence of interference in a selected RF channel, comprising:

(a) generating a received signal strength indication (RSSI) measurement corresponding to the RF signals present on a selected RF channel;

(b) tracking noise and interference estimates for each of the plurality of RF channels, wherein the noise and interference estimates are derived from the RSSI measurements generated in step (a); and

(c) indicating that interference is present on a selected channel if the interference estimate tracked for the selected channel in step (b) exceeds the noise estimate tracked for the selected channel in step (b) by a threshold value.

51. The method of detecting interference in a wireless communication system as set forth in Claim 50, wherein the step (c) of indicating that interference is present on a selected RF channel comprises the following sub-steps:

(1) scaling the noise estimate tracked in step (b) for a selected RF channel by a predetermined scale factor;

(2) comparing the scaled noise estimate to the interference estimate tracked for the selected RF channel; and

(3) indicating that interference is present on the selected RF channel if the interference estimate is greater than or equal to the scaled noise estimate, else indicating that interference is absent from the selected RF channel.